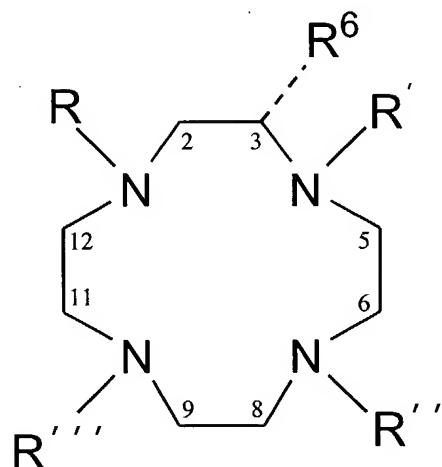


WHAT IS CLAIMED IS:

1. A magnetic resonance contrast agent comprising:
2 a tetraazacyclododecane ligand having a general structural
3 formula as follows:



4
5 and comprising a macrocyclic ring and wherein pendant arms
6 R, R', R'' and R''' attached to a ring nitrogen have the general
7 formula: $-C'HR^1R^2$ and for three or more of said pendant arms a
8 chirality of said carbon atoms C' are identical for each of said
9 three or more pendant arms, said R¹ are groups larger than
10 hydrogen, and said R² is selected from the group consisting of:
11 an alcohol (-CH₂OH);
12 amides (-CONR³R⁴, where R³ and R⁴ are organic groups);
13 a carboxylate (-COOH);

14 phosphinates (-PO₂HR⁵, where R⁵ is an organic group);

15 and

16 a phosphonate (-PO(OH)₂); and

17 wherein one or more of substituents R⁶ is a group larger

18 than a methyl group and is located on one or more ring carbons;

19 and

20 a paramagnetic metal ion, coordinated to said

21 tetraazacyclododecane ligand.

2. The magnetic resonance contrast agent as recited

2 in Claim 1, wherein said chirality of said carbon atoms C'

3 provides said three or more of said pendant arms with a Λ or

4 Δ orientation, and wherein a chirality of a ring carbon bonded to

5 said one or more of substituents R⁶ provides said macrocyclic

6 ring with an identical orientation, $\lambda\lambda\lambda\lambda$ or $\delta\delta\delta\delta$, respectively,

7 said tetraazacyclododecane ligand thereby having a monocapped

8 twisted square antiprism coordination geometry.

3. The magnetic resonance contrast agent as recited

2 in Claim 2, wherein said R² group is said alcohol or amide, and

3 further including a water molecule associated with said

4 tetraazacyclododecane ligand and said paramagnetic metal ion,

5 said water molecule having a residence lifetime at about 298°K,

6 τ_M^{298} , of between about 1 and about 100 microseconds.

4. The magnetic resonance contrast agent as recited
2 in Claim 2, wherein said R² group is said carboxylate, and
3 further including a water molecule associated with said
4 tetraazacyclododecane ligand and said paramagnetic metal ion,
5 said water molecule having a residence lifetime at about 298°K,
6 τ_M^{298} , of between about 10 and about 100 nanoseconds.

5. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein said chirality of said carbon atoms C'
3 is controlled to provide said three or more of said pendant arms
4 with a Δ or Λ orientation, and wherein a chirality of a ring
5 carbon bonded to said one or more of substituents R⁶ provides
6 said macrocyclic ring with an opposite orientation, λλλλ or δδδδ,
7 respectively, said tetraazacyclododecane ligand thereby having a
8 monocapped square antiprism coordination geometry.

6. The magnetic resonance contrast agent as recited
2 in Claim 5, wherein said R² group is said alcohol or amide, and
3 further including a water molecule associated with said
4 tetraazacyclododecane ligand and said paramagnetic metal ion,
5 said water molecule having a residence lifetime at about 298°K,

6 τ_M^{298} , of between about 10 and about 5000 microseconds.

7. The magnetic resonance contrast agent as recited
2 in Claim 5, wherein said R^2 group is said carboxylate, and
3 further including a water molecule associated with said
4 tetraazacyclododecane ligand and said paramagnetic metal ion,
5 said water molecule having a residence lifetime at about $298^\circ K$,
6 τ_M^{298} , of between about 100 and about 500 nanoseconds.

8. The magnetic resonance contrast agent as recited
2 in Claim 5, wherein said R^2 group is said phosphonate or said
3 phosphinate, and further including a water molecule associated
4 with said tetraazacyclododecane ligand and said paramagnetic
5 metal ion, said water molecule having a residence lifetime at
6 about $298^\circ K$, τ_M^{298} , of between about 10 and about 100 nanoseconds.

9. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein said R^1 is a methyl group, said R^2 is said
3 carboxylate, and said R^6 is a *para*-aminobenzyl group and said
4 paramagnetic metal ion is Gd^{3+} .

10. The magnetic resonance contrast agent as recited
2 in Claim 10, further including a water molecule associated

3 with said tetraazacyclododecane ligand said water molecule
4 having residence lifetime at about 298°K, τ_M^{298} , of about 15
5 nanoseconds.

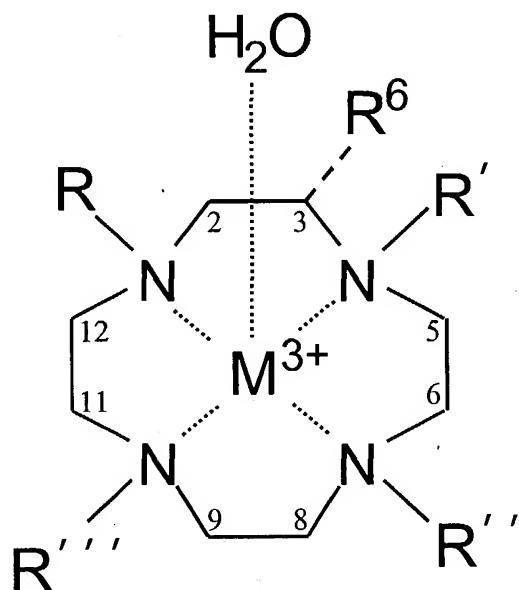
11. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein at least one of said one or more of
3 substituents R⁶ include a functional group selected from the
4 group consisting of:

5 amino groups;
6 carboxylates;
7 isothiocyanates; and
8 maleimides; and
9 a carrier component conjugated to said functional group.

12. The magnetic resonance contrast agent as recited
2 in Claim 1, wherein said paramagnetic metal is a lanthanide ion.

13. A method of using a magnetic resonance contrast
2 agent, comprising:

3 subjecting a contrast agent contained within a sample to a
4 radio frequency pulse wherein said contrast agent is a
5 tetraazacyclododecane ligand having a general formula of:



6
7 and comprising a macrocyclic ring and wherein pendant arms R,
8 R', R'' and R''' attached to a ring nitrogen have the general
9 formula: -C'HR¹R² and for three or more of said pendant arms a
10 chirality of said carbon atoms C' are identical for each of said
11 three or more pendant arms, said R¹ are groups larger than
12 hydrogen, and said R² is selected from the group consisting of:
13 an alcohol (-CH₂OH);
14 amides (-CONR³R⁴, where R³ and R⁴ are organic groups);

15 a carboxylate (-COOH) ;
16 phosphinates (-PO₂HR⁵, where R⁵ is an organic group) ;
17 and
18 a phosphonate (-PO(OH)₂) ; and
19 wherein one or more of substituents R⁶ is a group larger than a
20 methyl group and is located on one or more ring carbons; and
21 wherein said tetraazacyclododecane ligand further includes a
22 paramagnetic metal ion (M³⁺) coordinated to said
23 tetraazacyclododecane ligand and a water molecule (H₂O)
24 associated with said tetraazacyclododecane ligand; and
25 obtaining a magnetic resonance signal by applying a radio
26 frequency pulse at about a resonance frequency of water.

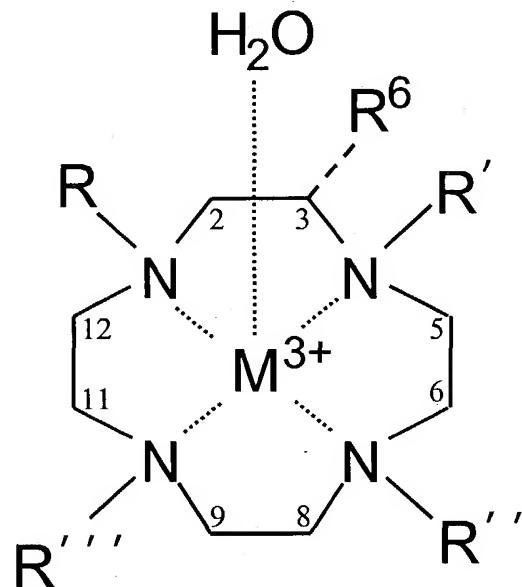
14. The method as recited in Claim 13, further includes
2 producing a magnetic resonance image from said magnetic
3 resonance signal.

15. The method as recited in Claim 13, wherein said
2 contrast agent further includes a carrier component conjugated
3 to said one or more of substituents R⁶.

16. The method as recited in Claim 15, wherein
2 said water molecule has a relaxivity at 298°C, r₁²⁹⁸, of at least
3 about 50 mM⁻¹ s⁻¹.

17. A magnetic resonance system, comprising:

2 a magnetic resonance contrast agent, wherein said magnetic
3 resonance contrast agent includes a tetraazacyclododecane
4 ligand, having a general formula of:



5
6 and comprising a macrocyclic ring and wherein pendant arms R,
7 R', R'' and R''' attached to a ring nitrogen have the general
8 formula: $-C'HR^1R^2$ and for three or more of said pendant arms a
9 chirality of said carbon atoms C' are identical for each of said
10 three or more pendant arms, said R¹ are groups larger than
11 hydrogen, and said R² is selected from the group consisting of:
12 an alcohol ($-\text{CH}_2\text{OH}$) ;
13 amides ($-\text{CONR}^3\text{R}^4$, where R³ and R⁴ are organic groups) ;
14 a carboxylate ($-\text{COOH}$) ;

15 phosphinates (-PO₂HR⁵, where R⁵ is an organic group);

16 and

17 a phosphonate (-PO(OH)₂); and

18 wherein one or more of substituents R⁶ is a group larger
19 than a methyl group and is located on one or more ring carbons;
20 and wherein said tetraazacyclododecane ligand further includes a
21 paramagnetic metal ion (M³⁺) coordinated to said
22 tetraazacyclododecane ligand and a water molecule (H₂O)
23 associated with said tetraazacyclododecane ligand, wherein said
24 magnetic resonance contrast agent produces a magnetic resonance
25 signal when subjected to a radio-frequency pulse; and

26 a magnetic resonance apparatus configured to produce said
27 radio-frequency pulse.

18. The magnetic resonance system recited in Claim 17,

2 further comprising a sample that is a living subject and
3 said sample contains said magnetic resonance contrast agent.

19. The magnetic resonance system recited in Claim 17,

2 wherein said magnetic resonance apparatus produces a image of
3 said sample from said magnetic resonance signal.

20. The magnetic resonance system recited in Claim 17,

2 wherein said magnetic resonance contrast agent further includes

3 a carrier component conjugated to said one or more of
4 substituents R⁶ and said water molecule has a relaxivity at
5 298°C, r_1^{298} , of at least about 50 mM⁻¹ s⁻¹.